DOCUMENT RESUME

ED 097 272 SO 007 839

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TITLE Societal Development and the Expansion of Educational Systems.
SPONS AGENCY National Center for Educational Research and Development (DHEW/OE), Washington, D.C. Regional Research Program.
BUREAU NO BR-1-0523
PUB DATE Nov 73
CONTRACT OEC-9-71-0033(508)
NOTE 47p.

EDRS PRICE MF-$0.75 HC-$1.85 PLUS POSTAGE
DESCRIPTORS Cross Cultural Studies; Data Analysis; *Developing Nations; *Economic Development; *Education; *Educational Development; Educational Research; Longitudinal Studies; Models; Research Methodology; *Social Development

ABSTRACT

The study of the causal connections of national educational expansion and social and economic development raises a variety of theoretical and methodological problems. The research reported here concentrates on the latter. It is felt that, because it is expected that educational expansion affects economic development, complicated analysis strategies are called for. The strategy supported is that of a longitudinal investigation of the issue using a large sample of nation-states. Special problems concerning longitudinal analysis and the use of conventional cross-national data are discussed. Using a revised panel model and the data for 1950-1965, relatively strong effects of educational expansion on economic development are shown. These findings persist under a wide variety of modifications of the analysis structure and, further, appear to be inconsistent with a model in which both education and economic development are not causally related. (Author/KSM)

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ED 097272

Final Report

Contract No. OEC-9-71-0033(508)

SOCIETAL DEVELOPMENT AND THE EXPANSION OF EDUCATIONAL SYSTEMS

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November 1973

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Office of Education

National Center for Educational Research and Development
(Regional Research Program)

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ABSTRACT

The study of the causal connections of national educational expansion and social and economic development raise a variety of theoretical and methodological problems. The research reported here concentrates on the latter. Since it is expected that educational expansion affects economic development and the reverse, quite complicated analysis strategies are called for. We argue for a longitudinal investigation of the issue using a large sample of nation-states.

Special analysis problems concerning longitudinal analysis and the use of conventional cross-national data are discussed. This discussion leads to a revision of the conventional panel model. Using the revised model and data for the 1950-1965 period, we show relatively strong effects of educational expansion on ecomomic development. These findings persist under a wide variety of modifications of the analysis structure. Further, they appear to be inconsistent with a model in which both education and economic development are not causally related, but merely reflect an overall "modernization" trend.

The results of empirical analysis are consistent enough to lend encouragement to further more detailed work on the issue. In particular, it is now appropriate to begin to devise research to choose among the wide variety of theoretical models consistent with this baseline analysis.

EDUCATION AND ECONOMIC DEVELOPMENT: SOME BASELINE MODELS

1. Introduction

Formal education has expanded at a rapid rate throughout the world during the past twenty years. In virtually every nation both the proportion of the population ever in school and the average length of tenure in school has increased dramatically over this period. This pattern exists in a situation in which a variety of "modern" institutional and organizational forms have spread rapidly through the collection of human societies. Primary among these are bureaucratic forms of organization, the nation-state form of polity, the nuclear family, and industrial form of production. It is sometimes argued that these characteristics evolve together and spread together as a "modern complex." Yet, it is clear that the rates of spread of the variety of modern forms differ considerably. And, it appears that formal schooling as an organizational mechanism for training and socialization has spread at least as rapidly and with at least as much success than any other modern form of organization.

As formal schooling has expanded, educational institutions have become increasingly important elements of large scale social organization. They involve more and more members of national populations in their activities; they control larger and larger proportions of national expenditures; they dramatically affect the working of the labor market; and they introduce new or altered normative and symbolic elements into political organization. The causes and consequences of some aspects of such developments have been much discussed by economists (Blaug 1968, 1969; Machlup, 1970; Bowman and Anderson, 1968) and political scientists (Coleman, 1965). But the issues have only infrequently been addressed by sociologists (cf. Ben-David, 1962; Anderson 19 ; Collins, 1971). As a result the treatment of the possible causes and consequences of the expansion of schooling has received a partial treatment at best. It would appear to be of great potential benefit to our understandings of large scale social processes to uncover the major causal processes which lead to the growth of education and which follow from its expansion.

The causal structures involved are likely to be quite complex and a program of research on the issues will likely produce very complicated causal models. However, there is virtue in working with highly oversimplified models at the early stages of the model building process. In this spirit we analyze separately the causes and consequences of the expansion of educational systems. Elsewhere (Rubinson 1973; Ramirez 1973; Warren, 1973) members of our research group have presented analyses of the former. Here we concentrate on the consequences of educational growth. But, the number o institutional areas presumed to be interrelated with educational institutions is so large and thus the number of possible social organizational connections so great that we are forced to further limit the scope of our inquiry. In the relevant literatures a disproportionate amount of attention is paid to the economic consequences of educational expansion. Since our concern is with evaluating the assertions made concerning education and social organizational consequences, it is useful to begin with this particular issue. Thus, we investigate the effects of expanding national educational systems on the workings of national systems of production.

This problem can be approached from a wide variety of theoretical perspectives as we shall see in the next section. Yet, virtually all of these approaches lead to the conclusion that educational expansion should have positive effects on the productive system. In a time when most social scientists and policy makers felt confident that education increased the productive capabilities of individuals, an analogous assertion at the nation state level seemed unproblematic. And, in fact, the expansion of educational systems for the explicit goal of increased economic development has been an almost universal social policy in recent years for most nations. But, as doubts about the causal importance of education at the individual level mount up (cf. Berg, 1971), the hypothesis of positive effects at the national level may now seem more problematic. If the expansion of educational institutions has no systematic consequences for the structure and functioning of production systems, there would be no point in constructing elaborate attempts to choose among the set of theoretical perspectives. If, and only if, educational growth can be shown to have such consequences is such further research and associated theoretical activity recommended.

Thus we take on the relatively simple problem of using longitudinal data on many nations to assess the plausibility of simple causal models which incorporate economic effects (at the nation state level) of educational growth. We find consistently positive effects in simple models. Thus most of the research reported here deals with possible methodological difficulties which would lead to such empirical results in the absence of "real" causal effects. This leads to a heavy methodological emphasis.

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2. Models of Educational Effects

There are at least four ways of approaching the problem of explaining the effects of educational institutions on production systems. These approaches differ both in the units of analysis for which the causal process is presumed to operate and the way in which the causal process occurs.

A. Aggregative Individual Approaches

Perhaps the most common approach is to propose that aggregate effects occur via a two step process. In the first step it is assumed that education changes individuals who are exposed to it. Usually two kinds of intra-individual changes are invoked: learning of specific skills (e.g. literacy) and socialization to standards and rules of procedure. In the particular case under study (effects on production systems) it is assumed that education produces changes which yield increases in individual productive capabilities. Thus the skills presumed to be transmitted are those which are directly employed in production (e.g. literacy) and socialization is to orientations which make possible a rational technical production process (e.g. socialization to "modern" time orientations). The second step in the process is that such individual changes are aggregated so that it is assumed that the productivity of the workforce increases as each new cohort of entrants increases in educational achievement (and thus, by step one, productivity).[1]

There is a version of the logical fallacy of composition involved in making the analogy from individuals to nations in terms of response to increases in level of education. That is, it is hazardous to reason from a specific finding of educational effects at the individual level to specific effects at the national level. This difficulty has by now been recognized in the economics of education literature and attention is now more often focused on studies of the relationship of levels of education to earnings at the individual level.

Whatever the logical merits of the case, the question remains whether or not possible effects at the individual level have aggregate level consequences. The methodological problems are those of aggregation. In this case individuals are not analyzed but aggregates (populations within national boundaries) are. It can be shown that if all nations had identical distributions of individual educational achievement and productivity, analysis of national data would lead to the same inferences as analysis of individual data. This is a case that would correspond to the case of so-called "random grouping". But, it is obvious that not all nations have the same distributions on these variables, i.e. that there is a correlation between country of residence and educational and productivity levels. In such cases, one arrives at inferences from the analysis of aggregate data than would be drawn in analysis of individual data. Unfortunately, the direction and likely magnitude of the aggregation bias in this case depends on factors which are not known (Hannan, 1971). Thus all we can say is that some systematic relationship between national levels of educational enrollments and national productivity <u>may</u> be consistent with arguments formulated at the levels of individuals.

B. <u>Organizational Approaches</u>

The size expansion of educational systems introduces new or altered elements in the organization network comprising formal social structure. The activities of educational organizations in relationships with the remainder of the organizational network may improve the productivity of the society. Most interestingly, it may have such consequences independently of its ability (if any) to modify the intra-personal characteristics of its students. Perhaps the best example of this is the so-called "certification" activity. School systems by evaluating students on a common set of standards permit the rationalization of labor markets. Individual employers do not have to engage in as costly an information search to determine the relative capabilities of prospective employees but can rely on school certification. This procedure may result in an important information cost reduction and in an improvement of the quality of information available to employees. At the same time, the imposition of a common set of educational organizations within all regions of a national system facilitates the creation of (presumably more efficient) national labor markets.

C. Institutional Approaches

The creation and expansion of educational systems may activate "modern" norms and values within a society both among those who experience education and those who do not. For example, Meyer (1971 a,b) argues that the existence of salient educational systems sei to legitimate both the status and the actions of modernizing elites and to make possible the dissemination of modern purposes (like industrial development) through the population. What is distinctive about this style of argument is that it implies that education can be used symbolically to produce economic development (presumably whether or not those who have been educated are more productive than those who have not).

D. Ecological Approaches

From an ecological point of view the importance of education is that it formalizes mechanisms for transmitting information (cf. Duncan, 1964). Presumably education is more efficient at this than is the apprenticeship form of organization (both within and without the family) which it is replacing. Presumably many of the proposed individual level effects imply more efficient transmission through a large population of information relevant to the organization of production. Similarly, mechanisms like the certification effect cited in (B) permit more efficient uses of information. Further, the levels of scientific, technological and organization innovation and invention may depend on the levels of education. By altering the levels of general and technical knowledge in a population, expanded education may alter the probability distribution for the generation of innovations and inventions useful in the productive process (Lenski, 1970). In all of these specific ways, educational expansion can be seen as an organizational investment in information processing capacity which has potential effects on economic development.

For present purposes what is most interesting about the above collection of causal assertions is that all of them argue for a positive effect of the expansion of education on economic development.[2] Thus it might appear that one is studying the obvious in making further inquiries into this matter. But, this is not the case. The known relationship between high levels of economic development and high levels of education can arise through

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a variety of mechanisms other than those involving a causal effect of education on economic processes. Two specific alternative hypotheses appear rather frequently in the literature. The first considers "modernization" to be a process which unfolds in some manner (either through more or less independent evolution or diffusion from a modern world "center") and considers high productivity and a great deal of formal education to be two manifestations of the same general process. In other words, it is assumed that a complex bundle of modern social structural features evolve or diffuse together as a "package". If this is true, changes in one of the two indicators of structural modernism (say education) will not produce changes in the other (in this case, economic productivity). The second possibility is that economic growth produces structural changes which result in increases in formal education but that increases in the scale of the educational enterprise play no causal role in changes in national productivity.

The empirical analysis which follows involves constructing, testing and estimating (where appropriate) longitudinal causal models which are appropriate to each of the three conceptions of the role of education expansion in economic development. There are a variety of somewhat specialized methodological problems which arise in attempts to conduct such an analysis with longitudinal data on nation states. We turn first to a discussion of these issues.

3. Methodological Issues

A. Unit of Analysis

The choice of proper units of analysis for research on the main question posed is a complex problem. Each of the different theoretical orientations suggests a somewhat different empirical focus. By far the largest contrast is between that implied by the individualistic models and the others. These differences suggest that there may be no uniquely best unit of analysis for studying this set of issues. However, we argue that among the available choices, one -- the nation state -- offers more advantages than any other single choice.

The main issue in selecting units of analysis for empirical research is whether or not a proposed unit is bounded in terms of the process under study. A system is bounded when the unit is large or complex enough that the entire hypothesized process can be worked out within the unit. It is always simpler to discuss lack of boundedness. For example, states (say within the United States) might be weakly bounded with respect to the effects of education on economic development if rates of migration were high enough that persons educated in a given state were unlikely to be employed in that state. From the perspective of a concern with education and productivity at anything other than an individual level, it is probably the case that nation states are the minimally bounded units (that is that the choice of any unit less inclusive than the nation state is inferior to the choice of the nation state).

There are two reasons why nation states are probably the minimally bounded units for this research. Previous research (Rubinson, 1973 and Ramirez, 1973) indicates that for the vast majority of nations in the world the administration of education including decisions about expanding education, occur at the nation state level. Secondly, it is less clearly the case but probably true that for most nations, crucial production decisions tend to be formulated at the national level. If either of these assertions is true, units less inclusive than the nation will imperfectly reflect the processes of interest.

Alternatively, there is growing concern that the nation is not an inclusive enough unit for the study of comparative social organization especially economic and political organization. We admit that this is a salient possibility and that one should attempt to replicate the present study with data aggregated for meaningful clusters of nation states or for other complex clusters of formally defined political entities (distinguishing, for example, between center and periphery of each nation (cf. Galtung 1971)). This proposal poses enormous additional research issues since what are the meaningful units is not yet understood. Our inclination is not to delay the present analysis while we and other groups of researchers grapple with supra-national social organization. Thus we choose to study the relations of economics and education with observations collected on nation states.

B. Panel Analysis

Much of the reported empirical literature is cross-sectional. Cross-sectional analysis presents some serious difficulties in the face of the likely (or at least hypothesized) event that the educational and economic variables are involved in a reciprocal causal relationship (that is where changes in one variable produce changes in the other and vice versa). In the face of this likelihood one cannot proceed with cross-sectional data and conventional statistical procedures, namely ordinary least squares regression. Two possibilities are open to the researcher in this situation. One can either retain the cross-sectional data structure and search for "instrumental variables" which directly affect one but not both of the reciprocally related variables. If such instruments are available in some minimal pattern, one can apply simultaneous equations estimation procedures to estimate effects of each of the original pair of variables on the other. Alternatively one can collect longitudinal observations and, making somewhat different assumptions, estimate the over-time effects of each variable on the other.

We have chosen to complicate the analysis in the direction of employing longitudinal observations. This choice was made because of our uncertainty about the interrelations of other social structural variables with the two variables under study. The state of the art in quantitative social structural analysis is such that we have little confidence in the assumption that any given variable has a (hopefully large) direct effect on, say, the size of the educational system but no direct effect on national productivity. We do not mean to imply that by employing longitudinal designs we are somehow escaping the necessity of making assumptions to generate interpretable results. Rather we feel more confident in the present instance that the assumptions required in the panel design are more plausible than those required in a cross-sectional non-recursive model.

We are using a panel design since we have collected observations on many units (instances of a process) at only a few points in time. Thus we employ not the usual time series framework but an extension of cross-sectional logic to the case where one has a time series of cross-sections. Consider the four-variable panel model in Figure 1. This appears to be the

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Figure 1 Here

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causal model implied by the sociological literature on cross-effects in panel analysis. Observations are available at two "waves" on a set of observations on two variables X and Y. Duncan (1969) has shown that this model with instantaneous reciprocal and lagged reciprocal causation contains too many parameters to be successfully estimated from any set of data (is under-identified). If this is the model to be analyzed, one must engage in the instrumental variables strategy mentioned above. We have chosen rather to rule out instantaneous causation, that is to set λ and μ equal to zero in the model drawn in Figure 1. This simplification (if appropriate) results in identification so that one may then proceed to estimation.

In the present case making this pair of simplifying assumptions does not evidence a grasping at methodological straws but rather follows from substantive considerations. The social structural processes (of economic development and educational expansion) are highly unlikely to react instantaneously to all but the most catastrophic events. On the whole they will tend to change incrementally and cumulatively as new members enter the systems with increased skills, as new technologies gradually replace older ones, as normative elements diffuse through a population and become institutionalized. In all such processes, instantaneous change at the macro level should be the exception rather than the rule. In this sense the panel model with lagged causation is highly appropriate on substantive grounds. Thus we proceed with the model as revised in Figure 2.

Figure 2 Here

At the moment we are considering only the effects of education on productivity. For that reason we consider only a single equation from the recursive system depicted in Figure 2. If we let Y denote some indicator of productivity and X some measure of educational scale, then the model we use is

$$Y_{t+k} = \beta_0 + \beta_1 Y_t + \beta_2 X_t + U_{t+k} \qquad (1)$$

Among the potentially important elements in the specification of the model in (1) is the length of lag period, k. It is commonplace to assert that lag models with inappropriate lag structures will lead to faulty inference. The problem as it arises in our research is much less serious than in most applications of such models. The autoregressions are so large relative to the cross-effects, that information on cross effects is "preserved" over long periods of time (Hannan, Rubinson and Warren, 1974). In this case the model will allow us to distinguish cross-effects. What we cannot claim is that the fifteen year period is meaningful from a causal perspective. Our results are consistent with much shorter causal lags. That is, we may be estimating the cumulation of shorter-lagged effects. Rather the problem we face is that macro institutional characteristics are very stable over time. The inertia produced by cumulative change processes is so high that if one employs a short time lag, the almost no "turnover" will be observed in the dependent variable(s). Since we have no a priori knowledge of the true lag structure, we begin with the longest lag which will permit us to analyze a sample of nations with widely varying cultural, geopolitical and social characteristics (that is which maximize variation on "background" variables of substantive interest). This leads us to choose the period 1950-1965, a fifteen year lag.

Note that (1) is a stochastic difference equation which contains a lagged dependent variable. This sort of model involves some special estimation problems. Ordinary least squares regression analysis is appropriate only under the assumption that the disturbance E is uncorrelated with the independent variables in any equation. But the disturbance term in (1) is a collection of unobserved causes of Y_{t+k}. It is a reasonable hypothesis that these same variables were causally important in determining values of Y_t. We have already alluded to the stability of institutional characteristics and should be prepared to find that these excluded causes of Y are themselves stable over time. This leads to the specification in Figure 3.

Figure 3 Here

Note that under the specification in Figure 3, U_{t+k} will tend to be correlate with Y_t. Thus if this is the correct specification, the disturbance in (1) will be correlated with at least one regressor, Y_t. This is the usual methodological hypothesis for the case of regressions with lagged dependent variables.

In general the inclusion of lagged dependent variables leads to bias in ordinary least squares estimators. This arises because least squares under these conditions "assigns credit" to the lagged dependent variable for the stability in the unobserved causes of the dependent variable. The bias is upwards in the three variable case when the disturbances are positively correlated over time (Johnston, 1972:307-320). Upward bias leads one to conclude that the dependent variable experiences greater "autonomous change" than is the case in the population.

A number of methodological proposals exist for rectifying this problem. All of them require relatively strong assumptions about the time dependence of the disturbances. Since we lack any dependable information on this matter, it is not clear that we would gain anything by replacing ordinary least squares by one of the available alternatives.[3] Thus we apply ordinary least squares with the expectation that our estimates of the autoregression, β_1, will be biased upwards.

Our substantive concern is not so much with the autoregression with the possible "cross-effects," than is with the effects of education on economics. Thus we are not directly concerned with bias in the autoregression term. The more immediate question is whether this situation results in any bias in the least square estimate of β_2. A comprehensive answer to this question would require a considerable statistical digression. However, for the three variable case at hand, we can pose the likely result.

Possible bias in β_2 depends on the collinearity (intercorrelation) of Y_t and X_t. The model as depicted in Figure 3 contains a curved arrow at the left hand side of the model to denote that Y_t and X_t are correlated due both to the existence of the presumed causal effect of X on Y but also for a variety of other reasons. In the analysis we report the magnitude of such correlations are ordinarily fairly high. Thus we must consider the consequences of high collinearity in a model of this form. The first consideration is that collinearity by itself does not result in least squares bias. Rather, high intercorrelations of regressors increase estimated standard errors (reflecting the increased uncertainty in estimation produced by collinearity) which makes it more difficult to obtain statistically significant results (Johnston, 1972:159-168).

But, collinearity in the presence of bias in estimates of β_1, results in bias in estimates of β_2. This arises as follows. Collinearity in the simple three variable case yields a negative correlation between the two estimators, β_1 and β_2 (Johnston, 1972:161). The higher the correlation of Y_t and X_t, the stronger the negative correlation between estimated values of the two coefficients. Since we know that estimates of β_1 are biased upwards, it follows that estimates of the cross-effect, β_2, are biased <u>downwards</u>. The magnitude of this bias depends both on the degree of collinearity and on the magnitude of bias in the estimate of the autoregression term, β_1. This leads us to conclude, at least for the three variable case, that we are providing conservative estimates of the effects of education on productivity. The situation is in fact more complicated than this. The analysis just presented presumes that X_t is uncorrelated with U_t. From the point of view of the equation we are analyzing, this seems an appropriate assumption. But, since we expect cross-effects in both directions (as in the model drawn in Figure 2), X_t depends on Y_{t-k} and thus on U_{t-k}. Consider the model drawn in Figure 4. In this

Figure 4 Here

case the correlation $r_{Y_t, U_{t+k}} = \rho\gamma$ while the correlation $r_{X_t U_{t+k}} = \rho^2\lambda\gamma$. As long as $|\rho|<1$ and $|\gamma|<1$, $|r_{Y_t U_{t+k}}|>|r_{X_t U_{t+k}}|$. If ρ is not very close to unity and γ is small (as we expect in this case for both cross-effects), the correlation of X_t and U_{t+k} will be small relative to that of Y_t and U_{t+k}. In this sense it may not be misleading to proceed as if X_t and U_{t+k} were uncorrelated.

C. Regression With Ratio Variables

Virtually all of the empirical literature we follow employs ratio variables in examining the substantive question under discussion. Typically, productivity is measured as GNP per capita and educational expansion as number of students in school per school aged population, etc. Recently a number of sociologists have noted methodological difficulties which arise in the regression of such compound variables (Freeman and Kronenfeld, 1973; Schuessler, 1973; Fuggitt and Lieberson, 1973).

Rather than engage in technical discussion of the general issue, we will consider a simple case. Consider the autoregression of GNP per capita on itself at an earlier point in time. This relationship is estimated by a single coefficient. But, from a causal perspective, it is obvious that there are many complicated possibilities. The estimate combines the two autoregressions (in GNP and in population) and the two cross-effects (the effect of GNP on population at a later point in time and the effect of population on GNP) into a single quantity. Viewed from this perspective it is not at all surprising that analysts are beginning to find the use of compound variables unsatisfactory. Of course, the number of complications increase exponentially as additional compound variables are introduced into the regression.

To propose a resolution to the problem we must ask why such compound variables were employed in the first place. There seem to be at least three reasons. First, there is in much macro research an implicit concern with "welfare" (in the economic usage of the term). Thus macro quantities are represented per capita to indicate what the total benefits or costs are per person in the system. Second, there is the recognition that population size (and other variables used in forming compound or ratio variables) are important causal agents in the process under study. The use of ratios is then a (misguided) attempt to "control" for the variables taken as denominators. Third, there may be theoretical reasons for defining variables which are compounds of more primitive variables. In the case at hand only the second motivation is obvious. We do not have specific welfare concerns and the minimal theory involved does not seem to require the use of ratios. In fact, we suspect that in many cases when ratios are specified on theoretical grounds in work on comparative social organization, the implicit motivation is with controlling for other variables. That is, it often appears simpler to introduce ratios into a single proposition rather than formulate two or three propositions defined on simpler quantities. In this case, we see that a considerable analysis price is paid.

Thus, we are led to consider simpler methods of "controlling" for population and other variables of potential importance. Our strategy is not to treat these as controls at all but to introduce such variables explicitly into the model. Thus the model for the autoregression of GNP per capita is respecified as in Figure 5.

Figure 5 Here

In the model in Figure 5 population is "controlled" in a covariance sense. That is GNP is "freed" of the effects of Pop_t and GNP_{t+k} is "freed" of the effects of Pop_{t+k}. In addition, if we are willing to assume that GNP has no instantaneous effect on Pop (where we allow an instantaneous effect in the other direction for "control" purposes), we obtain an additional analysis benefit. Since the "control" variable has been entered explicitly into the model we can examine its substantive effects. That is, one can consider the effect of GNP on Pop and the reverse.

In our analyses, the intertemporal correlations of the population variables are so high that multicollinearity presents serious problems. Given this, we appear to lose very little by eliminating one of the "control" variables from the model. Thus we analyze the model drawn in Figure 5,

Figure 6 Here

where Pop_{t+k} denotes population measured at time t+k.[4]

4. Data

The data used in the empirical analysis comes from the following sources:

Gross National Product (GNP): I.B.R.D. World Tables (1971). This source contains recent re-estimates of the data series for the entire 1950-1970 period. It is claimed that many of the serious errors contained in previously published tables of GNP have been detected and eliminated from the data. Further this reanalysis yields more cases than have previously been available for our initial measurement (1950). The variable is measured in millions of U.S. 1964 dollars.

Primary Enrollment (P): UNESCO Statistical Yearbook (1971): measured in thousands of enrolled students (that is, the raw figures are rounded to thousands). The educational series have also been recently recalculated to our advantage. The experts in the UNESCO Statistical Office claim (personal communication) that these series are the most comparable and reliable cross-national data series.

Secondary Enrollment (S): UNESCO Statistical Yearbook (1971): measured in hundreds of students.

Tertiary Enrollment (T): UNESCO Statistical Yearbook (1971): measured in tens of students.

Population (Pop): U.N. Statistical Yearbook (1971): measured in thousands of persons.

Government Revenues as a Percentage of Gross Domestic Product (GR): I.B.R.D. World Tables (1971). This variable is available only as an average over the period 1951-1960. In the text we refer to it as being measured in 1950 since if the averaging is appropriate, this is a good estimate of the 1950 value of the variable.

The means and variances of all variables are presented in Table 1. It is apparent in Table 1 that the number of observations available for each variable is not a constant. Thus the number of cases included in a regression varies depending on which independent variables are included. There are two main analyses: one containing GNP, the educational enrollments and population and second, one adding to those variables, government revenues. The number of cases is dramatically different in the two cases. Thus we present two correlation matrices, one relevant to each analysis. Table 2 contains the intercorrelations of GNP_{50}, GNP_{65}, P_{50}, S_{50}, T_{50} and Pop_{65}. Table 3 adds to those variables government revenues.

5. Empirical Analysis

In this section we attempt to analyze the models mentioned in earlier sections. We begin with the simplest possible models and then build towards more complex (but still quite simple) causal models. We continue to place a great deal of emphasis on the plausibility of the assumptions involved in each model.

A. Common Factor Models

Perhaps the simplest model proposed to explain the correlation of educational expansion and economic development is the common factor model. This argues that the two variables are not directly causally related but rather are two aspects of the same overall ("modernization") process. Presumably the general process is itself unobservable. It is not difficult to develop a mathematical representation of this argument but the unobservable variable structure will make it difficult to derive empirical implications without strong substantive assumptions. Our approach will be to construct a variety of such models and to bring into evidence data which is apprently inconsistent with at least the simplest versions of the common factor argument.

Let Y_{50} and Y_{65} denote GNP measured in 1950 and 1965 respectively, P_{50}, S_{50} and T_{50} denote the number of students enrolled in primary, secondary and tertiary schools respectively in 1950, and F_{50} and F_{65} be an unobservable factor. The simplest version of the "evolving common factor" model (Duncan, 1972) for primary education is the following:

$$
\begin{aligned}
Y_{50} &= \beta_1 F_{50} + U_1 \\
P_{50} &= \beta_2 F_{50} + U_2 \\
Y_{65} &= \beta_3 F_{65} + U_3 \qquad\qquad (2) \\
P_{65} &= \beta_4 F_{65} + U_4 \\
F_{65} &= \alpha F_{50} + \varepsilon
\end{aligned}
$$

Given the unobservable variable structure, it is not enough to assume that the disturbances in each equation in (2) are uncorrelated with the regressors. Additional assumptions are required for identification. Since nothing is known about the variances of the unobservable, the number of unknowns is usually reduced in the factor analytic approach by scaling all measured variables as standardized normal variates. This scaling implies that the variances of F_{50} and F_{65} are unity and that α is a correlation. Finally, it seems reasonable to assume that the causal structure relating each indicator to the unobservable is constant over time, that is that $\beta_1 = \beta_3$ and $\beta_2 = \beta_4$.[5] This entire set of assumptions yields an identified structure The revised model is diagrammed in Figure 7.

Figure 7 Here

The revised model implies that different indicators of the factor measured at the same point in time should be more highly correlated than different indicators measured at different points in time. This follows from the equations for the revised model:

$$Y_{50} = \beta_1 F_{50} + U_1$$
$$P_{50} = \beta_2 F_{50} + U_2$$
$$Y_{65} = \beta_1 F_{65} + U_3 \qquad (3)$$
$$P_{65} = \beta_2 F_{65} + U_4$$
$$F_{65} = \alpha F_{50} + \epsilon$$

Employing the rules for path analysis (Duncan, 1966), (3) can be rewritten:

$$r_{Y_{50}P_{50}} = \beta_1\beta_2 = r_{Y_{65}P_{65}}$$
$$r_{Y_{65}P_{50}} = \beta_1\alpha\beta_2$$
$$r_{Y_{50}P_{65}} = \beta_2\alpha\beta_1 \qquad (4)$$
$$r_{Y_{50}Y_{65}} = \beta_1^2\alpha$$
$$r_{P_{50}P_{65}} = \beta_2^2\alpha$$

Since α is a correlation, $|\alpha| \leq 1$. Thus

$$r_{Y_{50}P_{50}} \leq r_{Y_{65}P_{50}}$$

and equality obtains only when $\alpha = 1$.

Consider the correlation matrix presented in Table 4. Note that $r_{Y_{50}P_{50}} = .554$ while $r_{Y_{65}P_{50}} = .645$ (and $r_{Y_{50}P_{65}} = .372$). The same pattern holds for the relationships of secondary and tertiary expansion with GNP. Thus this highly simplified model is inconsistent with the data.

This is certainly not evidence strong enough to rule out completely the evolving common factor model. It is interesting to analyze to what extent weakening the assumptions recoups the situation. For the reason cited in footnote , the most denoteful element in the revised models is the requirement that factor-indicator paths be time-invariant. Hence we relax this assumption and return to the original specification (2). This can be rewritten:

$$
\begin{aligned}
r_{Y_{50}P_{50}} &= \beta_1\beta_2 \\
r_{Y_{65}P_{65}} &= \beta_3\beta_4 \\
r_{Y_{50}Y_{65}} &= \beta_1\beta_3\alpha \\
r_{P_{50}P_{65}} &= \beta_2\beta_4\alpha \\
r_{Y_{50}P_{65}} &= \beta_1\beta_4\alpha \\
r_{Y_{65}P_{50}} &= \beta_2\beta_3\alpha
\end{aligned}
\qquad (5)
$$

We see in (5) that no longer can a strong derivation concerning co-temporal and inter-temporal correlations be made. Specifically

$$r_{Y_{50}P_{50}} = \beta_1\beta_2 \text{ while } r_{Y_{65}P_{50}} = \beta_2\beta_3\alpha$$

and equality between them requires $\beta_1 = \beta_3\alpha$. Further, the inter-temporal correlation will be greater than the co-temporal correlation when $\beta_1<\beta_3\alpha$. Since $|\alpha|\leq 1$, this requires that $\beta_1<\beta_3$ which is entirely plausible. However, as α departs from unity, β_3 has to exceed β_1 by larger and larger magnitudes for this to hold. But since we know nothing a priori about the magnitudes involved we cannot rule out the common factor model.

But notice that the inter-temporal correlation $r_{Y_{50}P_{65}} = .372$ is less than the co-temporal correlation. This requires that $\beta_2>\beta_4$. The two results taken together imply that the causal (standardized) path from the modernization factor to education is increasing over time while that to productivity is decreasing.[6] This is a highly implausible situation. A variety of other modification of the evolving common factor model lead to the same implausible conclusion. In particular both of the models drawn in Figure 8 lead to this conclusion. (A) is an evolving common factor model which allows for "independent" stability in indicators and (B) one which allows for lagged effects from factors to indicators.

Figure 8 Here

None of the modifications of the evolving common factor model we have examined short of permitting the indicators to have direct causal effects on each other leads to plausible conclusions. This does not lead us to reject the possibility that such a model exists. Rather we conclude that such a model (if it exists) is at least as complicated as the models we will consider which contain causal relations among economic and educational variables. Since the primary interest in the common factor model is in its potential for simplicity, we gain very little by elaborating the analysis in the direction.[7] Thus we direct our attention to simple causal models relating economics and education.

B. Single Equation Models

The simplest single equation model consistent with the methodological principles discussed above is:

$$Y_{65} = \alpha + \beta_1 Y_{50} + \beta_2 P_{50} + \beta_3 Pop_{65} + U \qquad (6)$$

In all such cases (where Y_{50} and the educational variable, in this case P_{50}) are positively correlated we expect β_1 to be biased upwards and β_2 to be biased downwards. We have run separate regression equations for each of the educational variables. Thus unstandardized results are as follows:[9]

$$
\begin{array}{llr}
Y_{65} = 79.38 + 1.549\ Y_{50} + 4.507\ P_{50} - .158\ Pop_{65} & R^2 = .997 & \\
\qquad\qquad\qquad (.011) \qquad\quad (.150) \qquad\quad (.007) & N = 118 & \\
Y_{65} = 696.95 + 1.644\ Y_{50} + .602\ S_{50} - .006\ Pop_{65} & R^2 = .979 & (7) \\
\qquad\qquad\qquad (.033) \qquad\quad (.118) \qquad\quad (.012) & N = 117 & \\
Y_{65} = 1580.30 + 1.207\ Y_{50} + .851\ T_{50} + .003\ Pop_{65} & R^2 = .990 & \\
\qquad\qquad\qquad (.047) \qquad\quad (.068) \qquad\quad (.004) & N = 92 &
\end{array}
$$

Each of the educational variables has an estimated regression coefficient which is many times its standard error. Thus we would conclude from this set of regressions that educational expansion indeed has a positive effect on economic development for the period under study. But, there is a troubling instability in these regressions. Population has a large (relativ to its standard error) negative effect in the regression for primary but small effects in the remaining two regressions.

The instability in the behavior of population may be due to a mis-specification of the form of the relationship. Since GNP is highly skewed, the usual practice is to employ logarithmic transforms. Below we present a set of comparable regressions in log-linear form (that is where all variables are taken as logarithims to the base 10):

$$
\begin{array}{lll}
 & LOG\ Y_{65} = .808 + .978\ LOG\ Y_{50} + .093\ LOG\ P_{50} - .055\ LOG\ Pop_{65} & R^2 = .967 \\
(8) & \qquad\qquad\qquad (.038) \qquad\qquad (.041) \qquad\qquad (.042) & N = 118 \\
 & LOG\ Y_{65} = .747 + .950\ LOG\ Y_{50} + .065\ LOG\ S_{50} - .007\ LOG\ Pop_{65} & R^2 = .968 \\
 & \qquad\qquad\qquad (.047) \qquad\qquad (.029) \qquad\qquad (.035) & N = 117
\end{array}
$$

$$\text{LOG } Y_{65} = .811 + .876 \text{ LOG } Y_{50} + .078 \text{ LOG } T_{50} + .038 \text{ LOG } Pop_{65} \qquad R^2 = .976$$
$$(.042) \qquad (.020) \qquad (.034) \qquad N = 92$$

These regressions lead to identical conclusions with the exception that the population effect is small relative to estimated standard errors in all equations. What is most interesting is that the R^2 for each equation is less than the R^2 for the corresponding linear-additive equation. Further, examination of the residuals from the six regressions demonstrates a clear superiority for the linear-additive form.[8] This somewhat unexpected result continues to hold when other functional forms are tried (e.g. semi-log, reciprocal and logarithmic reciprocal transform). Thus we continue our attention for the remainder of the analysis to the linear-additive specification.

Given that primary, secondary and tertiary education all appear to have positive effects on GNP, it is interesting to examine whether these effects are analytically separable. Thus we introduce all three educational variables into the same regression:

$$Y_{65} = -397.748 + 1.564 Y_{50} + 4.664 P_{50} + .217 S_{50} - .092 T_{50} - .172 Pop_6 \tag{9}$$
$$(.033) \qquad (.299) \qquad (.048) \qquad (.067) \qquad (.012)$$
$$R^2 = .998$$
$$N = 91$$

The revised model leads us to revise our earlier conclusions. Now it appears that holding initial levels of GNP constant (in a covariance sense) both primary and secondary education increase GNP over a fifteen year period but that tertiary enrollments have a small (relative to estimated standard error) negative effect. The tertiary effect, however, is probably best judged to be nonexistent. Finally, population size in 1965 has a negative effect on GNP growth as would be expected.

The results for primary and secondary enrollments are rather striking. But, we anticipate objections to the relatively simplified model which generates these findings. Perhaps the most interesting objection is substantive. A critic might claim that the existence of a large educational system is evidence of the existence of powerful and effective state organization but that it is the power and efficacy of the state not education *per se* which accounts for economic development differentials. In other words, states which have the organizational (as distinct from economic) capacity to develop large systems of mass education will also tend to have the capacity to plan and implement effective strategies of economic development.

There are a number of ways in which to deal empirically with the state-power argument. Since we /are analyzing simple models here we will examine only the simplest of these. This is a model which allows for the effects of both education and a variable assumed to measure the organizational capacity of the state: government revenues as a percentage of gross domestic product (denoted GR_{50}). Our argument is that effective states will have the capacity to generate large amounts of revenues (and we might add, that the capacity to generate large revenues likely increases efficacy in other spheres). Unfortunately, the raw data from which these ratios were constructed is not available and we must analyze the ratios. Since GNP and GDP should be highly correlated, GR_{50} will be inversely correlated with GNP_{50}. By earlier arguments, the presence in the regression of lagged GNP will result in over-estimates of the effect of GR on GNP_{65}.

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More precisely the alternative model is that diagrammed in Figure 9.

Figure 9 Here

The model in Figure 9 is a two-equation model. However, we are presently treating the causal relation between GR_{50} and P_{50} (S_{50} and T_{50}) as an unanalyzed correlation. In either case, the important feature of the model is that it implies that controlling for GR, educational enrollments will have no direct effect on GNP_{65}. To study this we estimate a regression model as follows:

$$Y_{65} = -3362.03 + \underset{(.072)}{1.590}\, Y_{50} + \underset{(.890)}{4.417}\, P_{50} + \underset{(.119)}{.240}\, S_{50} - \underset{(.122)}{.130}\, T_{50} - \underset{(.023)}{.160}Pop_{65} + \underset{(.8894)}{1.3219}\, GR_{50}$$

$$R^2 = .998 \qquad (10) \qquad N = 53$$

This revised model (10) leads to no changes in the conclusions we have already stated. Although government revenues has a positive effect (not quite twice its standard error), the effects of primary and secondary education appear not to be diminished.

Note that the inclusion of GR_{50} reduces the number of cases from 91 to 53. No doubt this selection is not random but tends to choose those nations which are most economically developed. However, the estimates of the regression coefficients in (10) for the lagged dependent variable, the educational variables and population change very slightly, no more than we would expect on the basis of simple sampling variability.[10] We take this surprising stability to be supportive of the specification of the model in (9).

6. Discussion

We have demonstrated to our satisfaction that the persistent correlation of economic and educational development is evidence of at least a causal effect of the expansion of education on economic productivity. Simple models containing the empirical implications of direct causation lead to plausible conclusions. In particular, these conclusions are more plausible than those arrived at by reasoning that economics and education are correlated only because they reflect a common modernization process. Further, we find to our surprise that linear additive models relating education and economics in panel models are superior to a variety of more complicated models.

Our results are strongest for primary and secondary education. When all three educational variables are entered into the same regression equation, the effect of tertiary education is reduced to the point that we have no confidence in its estimate. Further, the strong positive effects of primary and secondary expansion continue to hold (essentially unchanged) when a variable which measures the power of the state (government revenues) is entered into the regression. This result is supportive of the simple causal model in two respects. First, it eliminates from serious consideration the rival model which claims that educational expansion merely reflects the organizational capacity of the state and has no independent causal effects on economic development. Second, the introduction of government revenues eliminates nearly half of the observations from the sample. But, the estimated coefficients for the four variables of interest (lagged GNP, primary, secondary, tertiary and population) are amazingly similar when estimated on this reduced sample in a regression containing government revenues. This stability is almost completely unexpected (and has rarely occurred in our analysis on other processes with similar data sets).

Further, the result in (9) stands up quite well when a variety of other social organizational variables are entered into the model. These results are not reported here since the continued expansion of single equation models is highly unlikely to lead to substantial insight into the structure of causation at the organizational and institutional level. These additional factors, if important, are likely to combine in complicated ways with education to affect economic development. To anticipate this possibility we must begin constructing <u>systems</u> of equations. The stage now appears to be set for such an extension. The purpose of the present analysis was to assess the feasibility of investing in such complicated modeling exercises. On the basis of the work reported here we conclude that such an extension is not only feasible but promises to yield substantia increments to knowledge.

Refinement of the work reported here requires further methodological analysis. There are two areas in which such work appears most urgently needed. First, since we incorporate lagged dependent variables into our regression equations, the presence of the expected autocorrelated disturbances produces least square bias. We are primarily interested in the presence of and likely magnitude of the bias in cross-effects. In the simplest models we can show (Section 3) that the bias the cross-effect is a negative function of the correlation of the lagged independent and lagged dependent variable. But, we expect cross-effects in both directions (that is, from education to economics and the reverse). For this reason the simplest model is not exactly appropriate. The bias in the cross-effects no longer depends solely on the collinearity to explanatory variables and bias in the lagged dependent variable. We suspect that under many conditions this additional complication does not lead to serious inference problems. However, this is merely a conjecture at this point. Work on this subject is essential for analysis of the type reported in this paper.

If we are willing to make assumptions about the behavior of the disturbances over time we can construct more elaborate analysis models which allow us to "condition" estimates of substantive effects on the presence of autocorrelated disturbances. The most promising approach for us appears to be the pooling of cross-sections over somewhat shorter time intervals. By employing all of the five year lags (say) in the 1950-1970 period, we will obtain measures on each unit at five points in time. The behavior of each of the hundred-odd five-observation time series can then be used to estimate the disturbance autoregression (cf. Nerlove 1971). Once this is achieved, we can apply generalized least squares or instrumental variables estimation to yield estimates of causal effects. Estimates arrived at in this manner should be superior from a statistical inference perspective to those reported here.

Inferences from ordinary least squares regression implicity assume perfect measurement in independent variables. While we have a great deal of confidence in the newly available cross-national data used here, it would be the height of foolishness to claim that it is error free. The effects of even random error can be specified a priori only for <u>two-variable</u>

models. If we are to consider measurement error, we must construct specific causal models containing both "true" scores and measured scores of variables. These models take the "true" scores as unobservable (cf. Costner, 1969; Hauser and Goldberger, 1971) and specify the relations between "true" scores and measured scores. The usual procedure is to employ "multiple indicators" of some or all of the unobservables in order to simplify the structure so that the causal effects of the unobservables (net of hypothesized measurement error) are estimable. Preliminary work along these lines has been completed (Hannan, Rubinson and Warren 1974). However, a variety of special estimation problems arise when unobservables are introduced into panel models with cross-effects. Further work is required if this strategy is to be fruitfully employed in the substantive research.

The next steps in the substantive research are also fairly obvious. In this paper we examined only one of the cross-effects in the education-economics structure. Baseline models for the effect of economic development on educational structure must be constructed and estimated. Work by our associates has shown that a variety of elements in national political structure (including state organizational efficacy) are important causal variables in the determination of educational expansion (Rubinson, 1973; Ramirez, 1973); further, they have shown (Warren, 1973) that ethnic heterogenity of the nation has systematic effects on educational expansion (net of economics and politics). The most interesting substantive problems arise in the effort to combine the two types of baseline models into a single coherent model relating educational and economic development. The work reported here is intended to be a step in this direction.

Table 1

Means and Variances of All Variables

	Mean	Variance	No. of Observations
GNP_{50}	6743.93	32778.49	127
GNP_{65}	13-43.07	57298.55	135
P_{50}	1445.00	4327.90	144
S_{50}	2971.70	9876.65	141
T_{50}	6701.54	26814.98	97
Pop_{65}	24085.74	77427.12	136
GR_{50}	205.62	74.16	59

Table 2

Correlation Matrix of Economic and Educational Variables and Population

	GNP_{50}	GNP_{65}	P_{50}	S_{50}	T_{50}	Pop_{65}
GNP_{50}	1	.986	.546	.656	.918	.308
GNP_{65}		1	.636	.709	.959	.346
P_{50}			1	.710	.728	.850
S_{50}				1	.734	.550
T_{50}					1	.397
Pop_{65}						1

N = 91

Table 3

Addition of Government Revenues to the Correlation Matrix of Table 2

	GNP_{50}	GNP_{65}	P_{50}	S_{50}	T_{50}	Pop_{65}	GR_{50}
GNP_{50}	1	.996	.783	.686	.979	.403	.175
GNP_{65}		1	.760	.644	.977	.396	.162
P_{50}			1	.914	.834	.838	-.038
S_{50}				1	.732	.712	.062
T_{50}					1	.493	.082
Pop_{65}						1	-.182
GP_{50}							1

N = 53

Table 4

Correlation Matrix of Educational and Economic Variables at Two Points in Time

	Y_{50}	Y_{65}	P_{50}	P_{65}	S_{50}	S_{65}	T_{50}	T_{65}
Y_{50}	1	.986	.554	.372	.662	.508	.918	.465
Y_{65}		1	.645	.442	.716	.633	.959	.452
P_{50}			1	.727	.723	.942	.729	.270
P_{65}				1	.524	.672	.555	.729
S_{50}					1	.643	.736	.345
S_{65}						1	.779	.195
T_{50}							1	.418
T_{65}								1

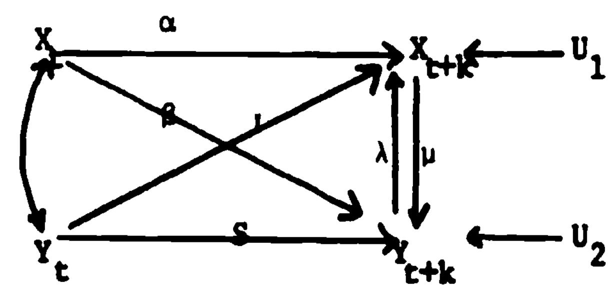

Figure 1

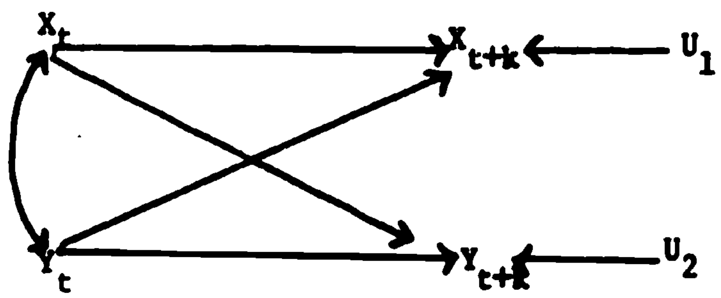

Figure 2

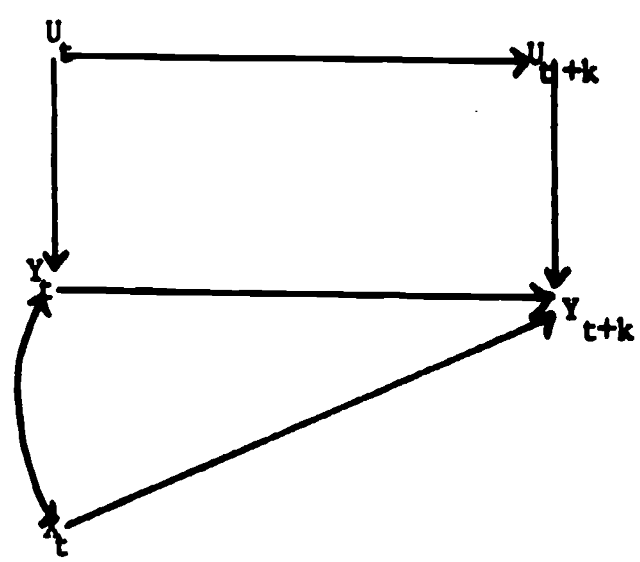

Figure 3

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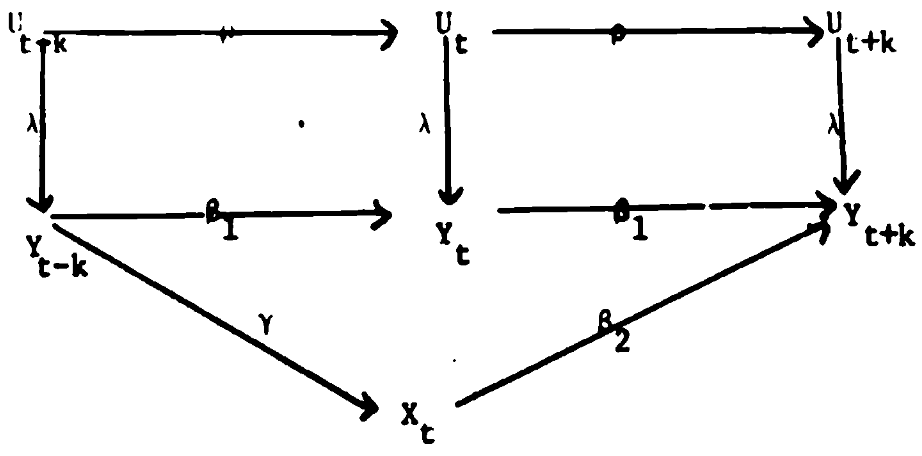

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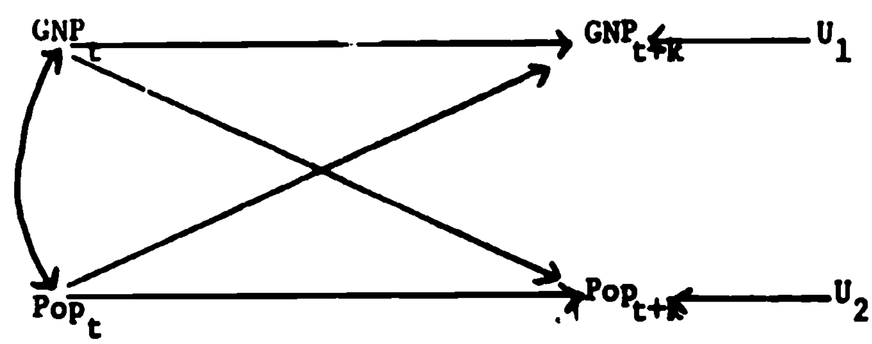

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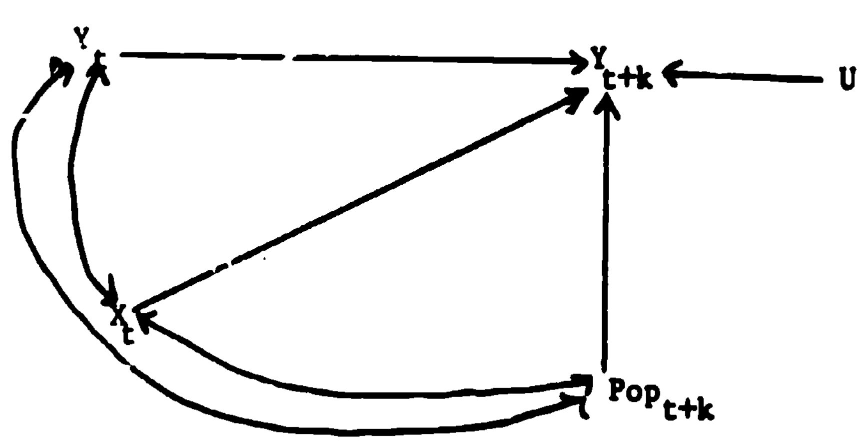

Figure 6

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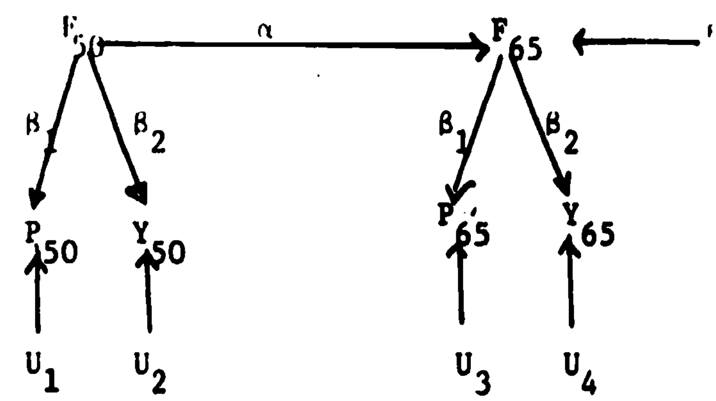

Figure 7

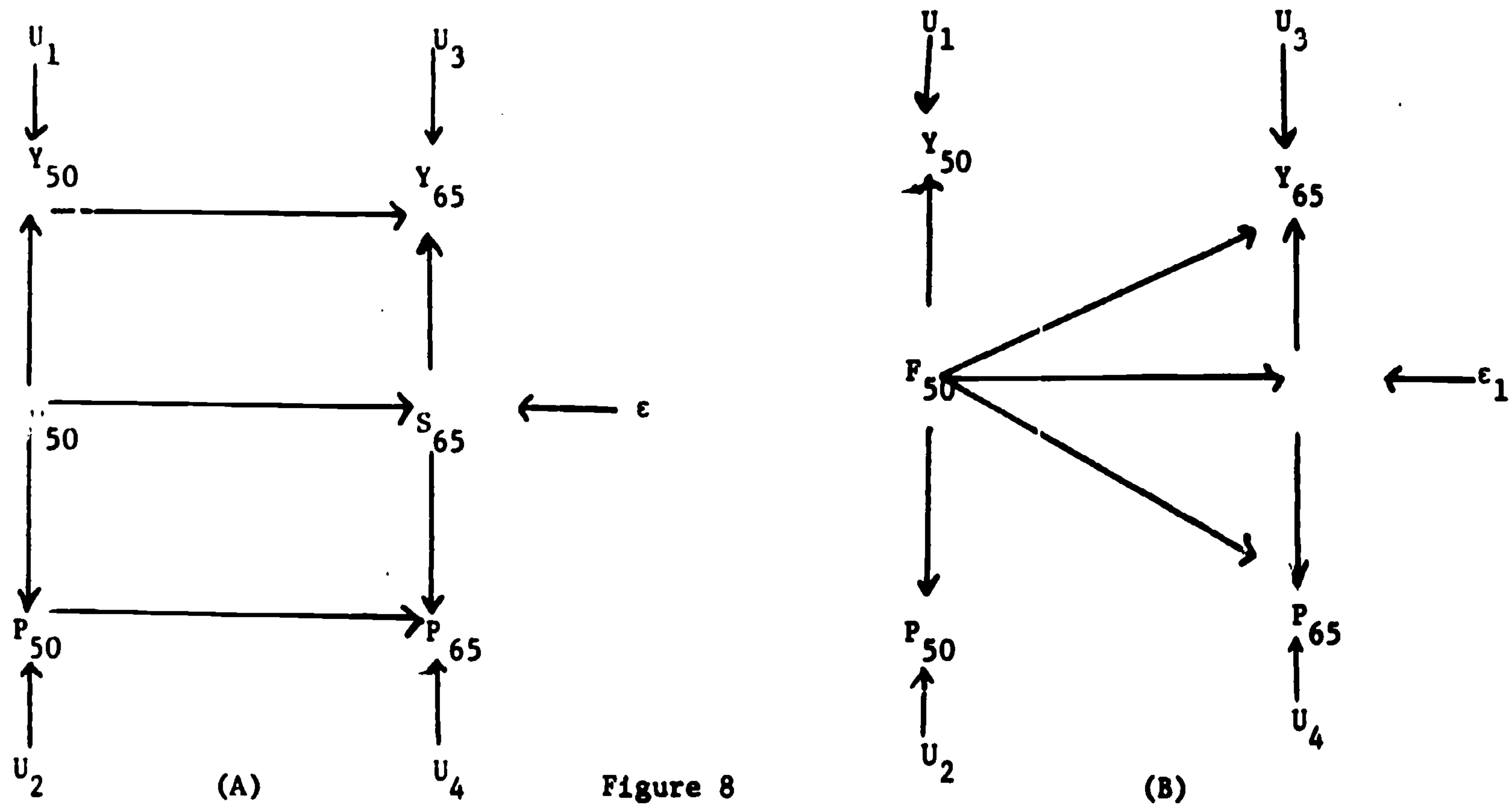

Figure 8

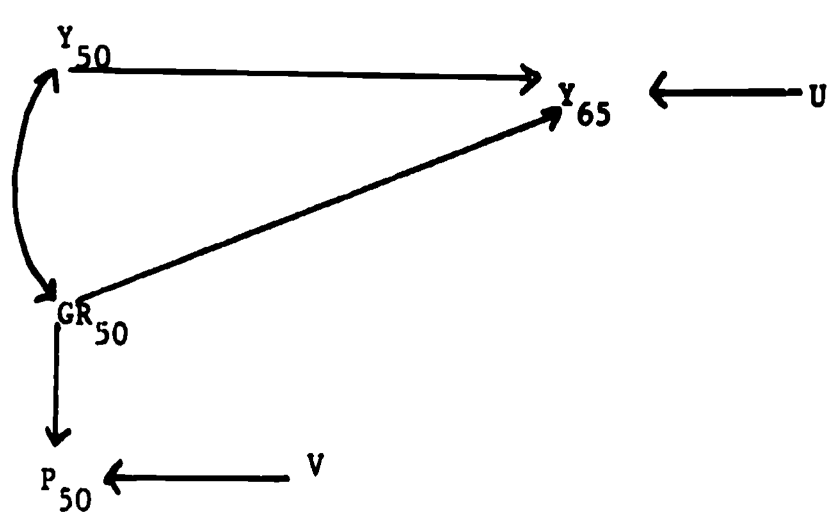

Figure 9

FOOTNOTES

[1] Machlup (1970) outlines a number of intra-individual changes which do not necessarily increase individual productivity but which in the aggregate might lead to increases in productivity. For example, if individual propensity to save increases with education and aggregate savings increase aggregate productivity, then educational expansion will cause increases in productivity via an effect on individuals.

[2] There are arguments in the literature for negative effects (e.g. Foster, 1965). But, this is clearly a minority position.

[3] In work which is in progress we are using the method of "pooling a time series of cross-sections" of shorter lag structure to deal with this problem.

[4] A further difficulty arises because the appropriate base for the educational variable, X, is ordinarily not total national population but some school-aged population. If every nation had the same age distribution, this would present no problems. But, this is obviously not the case. Introducing school aged population into the model creates severe collinearity problems. Thus we avoid doing this for the moment. One additional possibility is to use a combination of part-regression and partial regression. To regress X_t on the school aged population at time t and use residuals from that part-regression in the model drawn in Figure 6. This approach will be explored in forthcoming work.

[5] Unfortunately, while this assumption is useful for didactic purposes, it is not very useful for analysis. The standardized path coefficients are sensitive to changes over time in the variances of the indicators. Thus even though the causal structure is unchanged the values of the path coefficients may vary from period to period.

[6] The same pattern holds for 5 and 10 year time periods within the 1950-1965 period.

[7] It may be correctly argued (Duncan 1972) that the correct model is likely to be some combination of an evolving common factor model and a model positing direct causal effects. However, the use of unobserved variables will greatly complicate the following analysis. Thus we postpone for the present task of integrating the two kinds of models.

[8] It is apparently the case that since the extreme cases in 1965 are also extreme in 1950, the regression plane resulting from the inclusion of the lagged dependent variable alleviates some of the distributional problems.

[9] Estimates of standard errors appear in parentheses under slope estimates.

[10] The standardized path coefficients are much more variable as expected. The selective elimination of cases differentially affects variation in variables thereby affecting the estimated values of path coefficients. That data employed in this analysis demonstrate this problem in a rather remarkable way. The elimination of the United States from the sample reduces the variance in GNP by approximately one half. As a consequence the path coefficients with the U.S. eliminated changed dramatically (as much as five-fold increases and fifty percent decreases) while the estimated path regressions are essentailly unchanged. For this reason we do not report standardized path coefficients in this paper.

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